Application Report
SNOA548A–May 2010–Revised April 2013

AN-2006 Synchronizing a DP83640 PTP Master to a GPS Receiver

ABSTRACT

This application report discusses methods of synchronizing the precision time protocol (PTP) clock to a GPS receiver using the DP83640 precision PHYTER™.

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1 Introduction

The IEEE 1588 precision time protocol provides a means of synchronizing the time between multiple nodes using standard Ethernet connections. In many applications, telecommunications in particular, synchronization of the local time base is essential to system performance. In these applications, a GPS receiver is typically used to synchronize remote sites. This method, however, is expensive due to the cost of the providing a GPS receiver at each remote site. An alternate method is to utilize a single GPS receiver as the time base for an IEEE 1588 Master and synchronize the remote sites using the Ethernet and the IEEE 1588 precision time protocol.

2 Synchronization Methods

Synchronization can be accomplished using a DP83640 clock reference that is independent of the GPS receiver clock or that is dependent upon the GPS receiver clock source. The DP83640 reference clock for the pulse-per-second synchronization described in Section 2.1 is independent of the GPS reciever. The direct reference connection simplifies the control loop by taking advantage of the GPS receiver output clock.

2.1 Pulse-Per-Second Synchronization

The pulse-per-second synchronization method, shown in Figure 1, assumes that the GPS receiver is operating as a valid time reference.

A general outline of the steps required to synchronize the PTP clock to the GPS clock is as follows:

1. Initialize the PTP clock in the DP83640.
2. Configure a general-purpose input/output (GPIO) as an event monitor to detect the rising edge of the PPS output from the GPS receiver.
3. Upon detection of the first PPS event,
   (a) Capture the timestamp of the event.
   (b) Read the time from the GPS unit.
   (c) Calculate the difference between the GPS time and the PTP time and use a step adjustment to correct the PTP time.
4. Since the PPS output of the GPS receiver will occur at 1-second intervals, it should not be necessary to poll the GPS receiver for the time with each captured timestamp. However, to ensure continued accuracy of the system, the GPS and PTP times should be checked and verified periodically.

NOTE: The initial PPS event captured will most likely result in a large (> 1 second) delta between the GPS time and the local time of the DP83640. After the initial time adjustment, subsequent timestamps should be within a 1 second error and allow for temporary rate adjustments to further adjust the time of the PTP clock.

With this configuration, the 25 MHz reference used for the DP83640 will not track the reference of the GPS source exactly. As a result, the PTP clock will require rate corrections to compensate for differences in the reference clock rates. The rate correction can be calculated based on the difference in time stamps between sequential PPS edges.

In the case where the 25 MHz reference to the DP83640 is a voltage-controlled oscillator, it is possible to adjust the oscillator frequency based on the needed rate correction as an alternative to performing the rate correction to the PTP clock. In this instance, care should be taken in selecting a D/A converter that will provide sufficient voltage resolution to meet the system clock accuracy requirements.

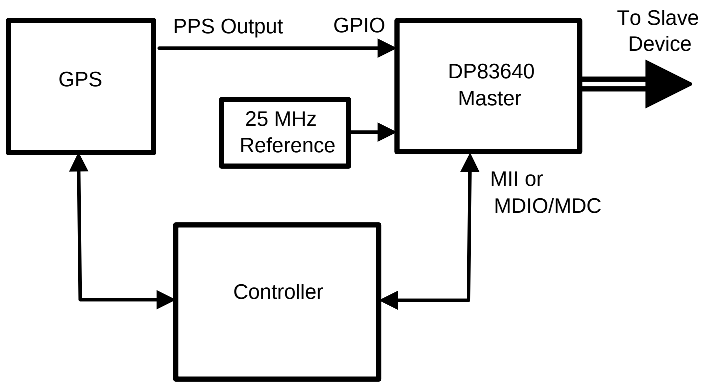

Figure 1. Block Diagram Using 25 MHz Reference not Cconnected to the GPS sSurce

2.2 Direct Reference Connection

The direct reference connection method, shown in Figure 2, assumes that the GPS receiver is operating as a valid time reference.

Initialization of the DP83640 PTP clock for the direct reference connection is the same as for the pulse-per-second synchronization. However, with the GPS 10 MHz time-base output used as the basis for the 25 MHz reference to the DP83640, the need to continually perform rate adjustments to the PTP clock is eliminated. To minimize reference clock jitter, the Texas Instruments LMK03000 device is recommended.

1. Initialize the PTP clock in the DP83640.
2. Configure a GPIO as an event monitor to detect the rising edge of the PPS output from the GPS receiver.
3. Upon detection of the first PPS event,
   (a) Capture the timestamp of the event.
   (b) Read the time from the GPS unit.
   (c) Calculate the difference between the GPS time and the PTP time and use a step adjustment.
4. Since the 25 MHz reference to the DP83640 is based on the 10 MHz output from the GPS source, there should be no drift of the PTP clock relative to the GPS clock reference. As such, there is no need to adjust the PTP clock using temporary rate adjustments.
5. With this configuration, there are still benefits to checking the PPS timestamps for accuracy. Since the resolution of the event timestamps is 8 ns, an improvement to the accuracy of the timing could be achieved by averaging sequential timestamps. Periodically checking the PTP clock against the GPS source can also guard against the possibility of a discontinuity in time from the Master.

NOTE: The initial PPS event captured will most likely result in a large (> 1 second) delta between the GPS time and the local time of the DP83640. After the initial time adjustment, subsequent timestamps should be within a 1 second error and no further adjustments to the time of the PTP clock should be required.

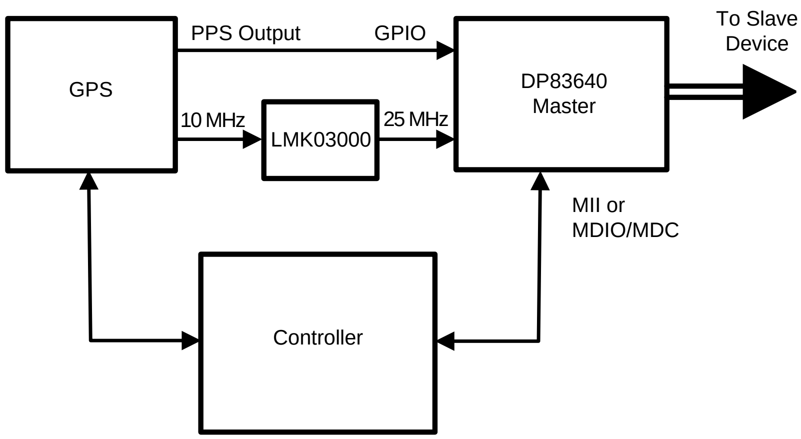

Figure 2. Block Diagram Using 25 MHz Reference Connected to the GPS Source

3 Summary

This application report presented two methods of synchronizing the IEEE 1588 PTP clock to a GPS clock source. Both methods provide an efficient means of synchronizing remote sites without the additional cost of a GPS receiver at each site. The pulse per second method achieves synchronization using a minimized hardware configuration supported by rate correction. The direct reference connection method achieves synchronization without the need for continuous rate correction through the addition of an LMK03000 device. Although both of the methods described above allow the PTP clock to be synchronized to the GPS clock, the direct reference connection method also allows the PHY to be a master for synchronous Ethernet operation with the transmit clock frequency being the same as the IEEE 1588 reference clock frequency.

For additional information related to the programming and synchronization of the DP83640, see Section 4.

4 References

- *DP83640 Precision PHYTER - IEEE 1588 Precision Time Protocol Transceiver Data Sheet* (SNOSAY8)
- *AN-1728 IEEE 1588 Precision Time Protocol Time Synchronization Performance* (SNLA098)
- *AN-1729 DP83640 IEEE 1588 PTP Synchronized Clock Output* (SNLA099)
- *AN-1730 DP83640 Synchronous Ethernet Mode: Achieving Sub-Nanosecond Accuracy in PTP Applications* (SNLA100)
- *Texas Instruments Ethernet PHYTER - Software Development Guide.*

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